02-29-00

A

02/28/00 JC714 U.S. PTO

PATENT APPLICATION TRANSMITTAL LETTER
(Large Entity)

Docket No.
END000006US1

TO THE ASSISTANT COMMISSIONER FOR PATENTS

Transmitted herewith for filing under 35 U.S.C. 111 and 37 C.F.R. 1.53 is the patent application of:

Donald S. Farquhar et al.

For: **ACCELERATED ETCHING OF CHROMIUM**

JC600 U.S. PTO 09/514526 02/28/00

Enclosed are:

- ☒ Certificate of Mailing with Express Mail Mailing Label No. **EL396831765US**
- ☒ 4 sheets of drawings.
- ☐ A certified copy of a application.
- ☒ Declaration ☒ Signed. ☐ Unsigned.
- ☒ Power of Attorney
- ☒ Information Disclosure Statement
- ☐ Preliminary Amendment
- ☒ Other: **Assignment and Assignment Cover Sheet**

CLAIMS AS FILED

For	#Filed	#Allowed	#Extra		Rate	Fee
Total Claims	30	- 20 =	10	x	$18.00	$180.00
Indep. Claims	2	- 3 =	0	x	$78.00	$0.00
Multiple Dependent Claims (check if applicable) ☐						$0.00
					BASIC FEE	$690.00
					TOTAL FILING FEE	$870.00

- ☐ A check in the amount of to cover the filing fee is enclosed.
- ☒ The Commissioner is hereby authorized to charge and credit Deposit Account No. **09-0457(IBM)** as described below. A duplicate copy of this sheet is enclosed.
  - ☒ Charge the amount of **$870.00** as filing fee.
  - ☒ Credit any overpayment.
  - ☒ Charge any additional filing fees required under 37 C.F.R. 1.16 and 1.17.
  - ☐ Charge the issue fee set in 37 C.F.R. 1.18 at the mailing of the Notice of Allowance, pursuant to 37 C.F.R. 1.311(b).

Dated: Feb. 25, 2000

Lawrence R. Fraley
Signature

Lawrence R. Fraley
Reg. No. 26,885
IBM Corporation
IP Law Dept. N50/040-4
1701 North Street
Endicott, NY 13760
(607) 755-3207

cc:

Express Mail #EL396831765US

APPLICATION

FOR

UNITED STATES LETTERS PATENT

APPLICANT NAME: Donald S. Farquhar *et al.*

TITLE: ACCELERATED ETCHING OF CHROMIUM

DOCKET NO.: END000006US1

INTERNATIONAL BUSINESS MACHINES CORPORATION

ACCELERATED ETCHING OF CHROMIUM

Background of the Invention

1. Technical Field

The present invention relates to a method and associated structure for increasing the rate at which chromium is etched when contacted by an acid solution.

2. Related Art

An etching of a chromium volume or chromium layer may be required during fabrication of a multilayer semiconductor structure such as a chip carrier. In some applications, a layer of photoresist covers portions of the chromium volume in order to produce a specified pattern. Further, a portion of the chromium volume must be removed using a chemical etchant, while at the same time leaving areas of the photoresist intact. The chemical etchant must have the property of removing all or part of the chromium volume while not attacking the photoresist. One etchant that meets this requirement is hydrochloric acid (HCl).

Known etching processes utilize a dip tank process for etching chromium from a laminated panel. However, horizontal conveyorized spray processing equipment offers greater throughput

and better integration with the rest of the manufacturing operation. Some special needs arise in conveyorized processing. For instance, some laminated panels (*i.e.*, thin ones) need to be set into a carrier fixture for processing. Also, one of the techniques used to increase etch rate in dip processes, the addition of a relatively high concentration of chloride salt, is not practical in a conveyorized spray process because of nozzle clogging and accumulation of salts throughout the apparatus.

A second problem associated with the related art is known as "undercut," wherein some edges of the layer of photoresist are undermined by the acid solution when the solution is left in contact with the chromium volume for excessively long periods of time required to produce the necessary amount of etching.

Thus there exists the need for a method to enhance the chromium volume etch rate so that the etch rate will keep pace with the remainder of the conveyorized process. There also exists a need for accelerating the chromium etch rate so that the undercutting of photoresist layers is minimized or eliminated by minimizing the total time that the panel spends in contact with the etching solution.

Summary of the Invention

The present invention provides a method for increasing a

rate at which a chromium volume is etched, said method comprising: providing said chromium volume that includes chromium, said chromium volume continuously contacted by an acid solution; and said chromium layer in continuous electrical contact with a metallic body, wherein the metallic body is continuously contacted by said acid solution; and etching the chromium volume.

The present invention provides an electrical structure, comprising: a chromium volume; an iron-comprising body in continuous electrical contact with the chromium volume; and an acid solution in continuous contact with both the chromium volume and the iron-comprising body, wherein the chromium body is being etched at an etch rate.

The disclosed method advantageously increases the etch rate of the chromium volume when contacted by an acid solution, such as in a spray etch process. By increasing the etch rate, the present invention also alleviates the problem called "undercut," wherein chromium is etched away from underneath the photoresist. Undercutting occurs when the etchant (*i.e.*, the acid solution) is permitted to have excessive contact with the chromium.

The foregoing and other features and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention.

Brief Description of the Drawings

FIG. 1 depicts a cross-sectional elevational view of a chromium body, a metallic body, and an acid solution, all in continuous mutual contact, in accordance with preferred embodiments of the present invention;

FIG. 2 depicts FIG. 1 after a layer of conductive metal has been conductively coupled to the chromium body, such that the layer of conductive metal is not in contact with either the metallic body or the acid solution; and

FIG. 3 depicts FIG. 1 after conductively coupling a layer of conductive metal to the chromium body, such that the metallic body and the acid solution each contact the chromium body through an opening within the layer of conductive metal.

FIG. 4 depicts a region of optimum operation of the method of the present invention, the region being defined by specific combinations of temperature and acid solution concentration.

Detailed Description of the Invention

FIG. 1 illustrates a cross-sectional elevational view of a chromium volume **14**, a metallic or iron-comprising body **22**, and an acid solution **24**, all in continuous mutual contact, the metallic body **22** also in continuous electrical contact with the chromium

volume **14**, in accordance with preferred embodiments of the present invention. The acid solution **24** is shown in FIG. 1 as a spray-deposited coating on a first surface **26** of the chromium volume **14**, but may be in any other form, such as in an immersion bath, so long as the acid solution **24** maintains continuous contact with both the chromium volume **14** and the metallic body **22**. Alternatively, the acid solution **24** may be applied to a second surface **28** of the chromium volume **14**, or to any exposed side **30** of the chromium volume **14**. Note that a chromium oxide layer **20** may exist on the chromium volume **14**, because the chromium volume **14** is prone to being oxidized by exposure to air. The metallic body **22** preferably includes steel.

An acid solution **24** that is effective for etching chromium includes a hydrochloric acid (HCl) solution having a molar concentration (*i.e.*, molarity, M) of at least about 0.3. Preferably, the molar concentration should not exceed about 6. At molar concentrations above about 6, care should taken to limit the etch time to a value low enough to insure that the etchant does not "undercut" any barrier material or photoresist, if present, such as a photoresist (not shown) above the chromium volume **30** or the chromium oxide layer **20**. The acid solution **24** should preferably be applied to the chromium volume at a temperature of at least about 35°C to ensure a sufficiently high

rate of etching. The temperature is preferably below about 70°C. At temperatures above about 70°C and below the boiling point of the acid solution **24**, the etch time should be sufficiently low so as to avoid the same undercutting as was described above for molar concentrations exceeding about 6. At temperatures above about 70 °C and near or at the boiling point of the acid solution **24**, care must taken to replenish evaporative losses of the acid solution **24**. Within these parameters such that the acid solution **24** includes hydrochloric acid and the metallic body **22** includes steel, etching rates between about 300 Å/min and about 3200 Å/min can be expected.

Etch rate tests have been conducted for chromium samples of thickness 800 Å such that the acid solution **24** includes hydrochloric acid and the metallic body **22** includes steel, with the temperature varying between about 21 °C and about 52 °C, and the hydrochloric acid solution's molarity (M) varying between about 1.2 M and about 2.4 M. The tests were conducted in the absence of NaCl in the acid solution. The results are summarized in Table 1 which follows.

Temp. (°C)	HCl Conc.* (M)	Stirring	Sparging	Etch Rate (Å/sec)	Etch Rate Ratio (w/ to w/o body **22**)
52	1.2	Yes	Yes	16.0	15.5
52	1.2	No	No	7.6	13.6
21	2.4	No	No	4.9	5.8
52	2.4	Yes	No	53.3	2.3
52	2.4	No	Yes	53.3	2.0

Table 1

* Note: Concentration of the HCl solution is its molarity (moles/liter).

The preceding table shows that the etch rate resulting from the use of metallic body **22** is at least a factor of about two greater than an etch rate that would occur in an absence of the metallic body **22**, which provides a substantial increase in etch rate as compared with currently known methods of etching chromium. As shown in Table 1, the etch rate ratio may be as high as about 15 if the temperature is high (*i.e.*, about 52 °C) and the HCl concentration is low (*i.e.*, about 1.2 M). The entries under "Stirring" indicate whether or not the acid solution was stirred during the entire time that the acid

solution was applied to the chromium test sample. Similarly, the entries under "Sparging" indicate that this technique (*i.e.*, forcing nitrogen gas (N_2) to bubble through the acid solution so as to sweep away air in order to reduce the amount of dissolved oxygen in the acid solution) was utilized for the entire time that the acid solution was in contact with the chromium test sample. Nitrogen sparging also has the effect of mixing the solution and is thus similar to stirring, with the additional effect of sweeping out the dissolved oxygen.

Note that the etch rate ratio, which is an indicator of the extent to which the present invention represents an improvement over currently known methods, is generally not very sensitive to stirring and sparging. An exception occurs when the temperature is low (*i.e.*, about 21 °C) and the HCl concentration is high (*i.e.*, about 2.4 M), such that there should be no stirring and no sparging in order to achieve the etch rate ratio shown.

FIG. 4 shows a domain of temperature and HCl concentration over which Table 1 applies. The present invention shows marked improvement in the chromium etch rate for those combinations of temperature (T) and HCl concentration or molarity (M) parameters which fall within the triangular region **82**. Triangular region **82** is defined by points **84**, **86**, and **88**, having the following temperature (°C) and molarity (M) coordinates (T,M): point **84** (21

°C, 2.4 M); point **86** (52 °C, 2.4 M); point **88** (52 °C, 1.2 M).

Other tests conducted in a conveyor spray etching apparatus, maintained at about 55 °C, indicated that the chromium volume was completely etched away when the sample was about fifty-five percent of the way through the apparatus, when a steel clip was attached to the chromium volume. Without the steel clip, the chromium volume was barely etched by the time the sample reached the end of the spray etching conveyor. These results again indicate an improvement in the etch rate of about two to one using a metallic body (*i.e.*, a steel clip) to accelerate the chromium etch rate versus not using the metallic body.

The mechanism for the increased etch rate facilitated by the metallic body **22** is as follows. An etching of chromium involves an oxidation reaction which ionizes a chromium atom, resulting in a positive chromium ion such as Cr^{+3} and free electrons. The chromium ion passes into the acid solution where it forms a chemical complex with the negative ion of the acid within the acid solution **24** such as with Cl^- of HCl. The free electrons react with hydrogen ions of the acid solution **24** to form hydrogen gas according to: $2H^+ + 2e^- \rightarrow H_2$. The metallic body **22** serves to enhance electron transfer from the chromium to the acid solution **24**; i.e., the electrons flow more readily through the metallic body **22** than from the chromium directly to the acid solution **24**.

The preceding explanation is supported by observations of hydrogen gas at steel surfaces for tests in which the metallic body **22** includes steel and the acid solution **24** includes hydrochloric acid.

It must be emphasized that the aforementioned increase in etch rate obtained with the present invention requires that, throughout the period during which the chromium volume **14** is etched, the metallic body **22** must be in continuous electrical contact with the chromium volume **14** and the acid solution **24**. Should the metallic body **22** be removed from its contact with either the metallic body **22** or the acid solution **24**, the etch rate will diminish appreciably.

The presence of a chromium oxide layer **20** on the chromium volume **14** does not inhibit the increased chromium etch rate of the present invention. Moreover, a given chromium volume **14** may be etched until it is effectively removed *in toto*, or the chromium volume **14** may be etched until a desired thickness is reached.

Although the acid solution **24** preferably includes hydrochloric acid, the acid solution **24** may generally include an acid from the halogen family of elements of the form HX, wherein X is fluorine, chlorine, bromine, or iodine.

FIG. 2 illustrates FIG. 1 after a layer of conductive metal

32 (*e.g.*, copper, aluminum, nickel, silver, gold) is conductively coupled to the chromium body **14**, such that the layer of conductive metal **32** is not in contact with either the metallic body **22** or the acid solution **24**. As described *supra* in conjunction with FIG. 1, the chromium etching process is enhanced by use of the metallic body **22**. As an application of FIG. 2, the layer of conductive metal **32** may function as a continuous internal sheet of conductive metal with the chromium body **14** serving as an adhesive interface between the layer of conductive metal **32** and a subsequently applied layer of dielectric material. In order to form through holes through a multilayered interconnect structure (e.g., a chip carrier) a hole must be etched in the chromium body **14** as well as in the layer of conductive metal **32**. The present invention, with inclusion of the metallic body **22** as described *supra*, enables the holes in the chromium body **14** to be formed with a high rate of etching.

FIG. 3 illustrates an alternative embodiment of the present invention. FIG. 3 illustrates FIG. 1 after a layer of conductive metal **42** (*e.g.*, copper, aluminum, nickel, silver, gold) is conductively coupled to the chromium body **14**, such that the metallic body **22** and the acid solution **24** each contact the chromium body **14** through an opening **34** within the layer of conductive metal **42**. Here, the chromium volume **14** is formed

beneath the layer of conductive metal **42** (*e.g.*, copper or aluminum). The opening **34** in the layer of conductive metal **42**, which extends through the thickness of the conductive metal **42**, may be fabricated using techniques known in the art. As described *supra* in conjunction with FIG. 1, the chromium etching process is enhanced by use of the metallic body **22**. As an application of FIG. 3, the layer of conductive metal **42** may function as a continuous surface sheet of conductive metal with the chromium body **14** serving as an adhesive interface between the layer of conductive metal **42** and a layer (not shown) of dielectric material (*e.g.*, a fluoropolymer dielectric) of a substrate to which the layer of conductive metal is to be affixed for forming surface conductive circuit lines. The layer of conductive metal **42** and the chromium body **14** must be etched in order to insulatively separate distinct circuit line segments within the layer of conductive metal **42**. The present invention, with inclusion of the metallic body **22** as described *supra*, facilitates etching of the chromium body **14** at a high rate.

Further alternative embodiments suggested by FIG. 3 include the use of multiple openings **34** and a corresponding number of metal bodies **22**. Each metallic body **22** will contact a unique chromium volume **14** or a portion thereof. Such multiple chromium volumes **14** are electrically isolated from one another.

While preferred and particular embodiments of the present invention have been described herein for purposes of illustration, many modifications and changes will become apparent to those skilled in the art. Accordingly, the appended claims are intended to encompass all such modifications and changes as fall within the true spirit and scope of this invention.

Claims

We Claim:

1. A method for increasing a rate at which a chromium volume is etched, said method comprising:

providing said chromium volume that includes chromium, said chromium volume continuously contacted by an acid solution;

said chromium volume in continuous electrical contact with a metallic body, wherein the metallic body is continuously contacted by said acid solution; and

etching the chromium volume.

2. The method according to claim 1, wherein said chromium volume includes an oxide of chromium and metallic chromium.

3. The method according to claim 1, wherein said metallic body includes steel.

4. The method according to claim 1, wherein said acid solution comprises hydrochloric acid.

5. The method according to claim 4, wherein said hydrochloric acid solution has a molar concentration between about 0.3 and about 6.

6. The method of claim 4, wherein said hydrochloric acid solution is maintained at a temperature between about 35°C and about 70°C.

7. The method of claim 1, wherein the acid solution is applied to the chromium layer as a spray.

8. The method of claim 1, wherein the acid solution is applied to the chromium layer in a dip bath.

9. The method of claim 8, wherein the acid solution is a mixture of sodium chloride (NaCl) and hydrochloric acid (HCl).

10. The method of claim 1, wherein the metallic body includes steel, wherein the chromium volume includes metallic chromium, wherein the acid solution includes hydrochloric acid, wherein a temperature (T) and a molarity (M) of the hydrochloric acid is within a triangular space defined by (T,M) points of (21 °C, 2.4 M), (52 °C, 2.4 M), and (52 °C, 1.2 M), and wherein the etch rate

is at least a factor of about 2 greater than an etch rate that would occur in an absence of the iron-comprising body.

11. The method of claim 1, wherein the iron-comprising body includes steel, wherein the chromium volume includes metallic chromium, wherein the acid solution includes hydrochloric acid, wherein a temperature (T) and a molarity (M) of the hydrochloric acid is within a triangular space defined by (T,M) points of (21 °C, 2.4 M), (52 °C, 2.4 M), and (52 °C, 1.2 M), and wherein the etch rate is at least about 5 Å/second.

12. The method of claim 1, further comprising forming hydrogen bubbles at a surface of the metallic body, said surface in contact with the acid solution.

13. The method of claim 1, wherein:

the metallic body includes steel;

the chromium volume includes an oxide of chromium and metallic chromium;

the acid solution comprises hydrochloric acid; and

the chromium volume is disposed upon a substrate, said substrate including a conductive metal, wherein selected areas of said conductive metal are exposed by the etching of the chromium

volume.

14. The method of claim 1, wherein the acid solution is includes an acid of a form HX, wherein X is selected from the group consisting of fluorine, chlorine, bromine, and iodine.

15. The method of claim 1, wherein the etching of the chromium volume is stopped when a portion of the chromium volume remains.

16. The method of claim 1, wherein the etching of the chromium volume continues until the entire chromium volume is removed.

17. The method of claim 1, further comprising bonding the chromium volume to a fluoropolymer dielectric volume.

18. An electrical structure, comprising:

a chromium volume;

an iron-comprising body in continuous electrical contact with the chromium volume; and

an acid solution in continuous contact with both the chromium volume and the iron-comprising body, wherein the chromium body is being etched at an etch rate.

19. The electrical structure of claim 18, wherein the chromium volume includes an oxide of chromium and metallic chromium.

20. The electrical structure of claim 18, wherein the acid solution includes hydrochloric acid in a liquid bath form.

21. The electrical structure of claim 18, wherein the acid solution includes hydrochloric acid in a spray form.

22. The electrical structure of claim 18, wherein said iron-comprising body includes steel.

23. The electrical structure of claim 18, further comprising a layer of conductive metal, wherein the chromium

volume includes a layer of chromium, and wherein the layer of chromium is on the layer of conductive metal.

24. The electrical structure of claim 18, wherein the acid solution is not in contact with the layer of conductive metal.

25. The electrical structure of claim 24, wherein the iron-comprising body includes steel, wherein the acid solution includes hydrochloric acid, and wherein the layer of conductive metal includes a metal selected from the group consisting of copper, aluminum, nickel, silver, and gold.

26. The electrical structure of claim 18, further comprising a layer of conductive metal, wherein the chromium volume includes a layer of chromium, wherein the layer of conductive metal is on the layer of chromium, wherein the conductive metal includes an opening extending through its thickness, wherein the opening exposes the layer of chromium, wherein the iron-comprising body is in continuous electrical contact with the chromium volume, and wherein the acid solution is in contact with both the iron-comprising body and the chromium volume within the opening.

27. The electrical structure of claim 26, wherein the iron-comprising body includes steel, wherein the acid solution includes hydrochloric acid, and wherein the layer of conductive metal includes a metal selected from the group consisting of copper, aluminum, nickel, silver, and gold.

28. The electrical structure of claim 18, wherein the iron-comprising body includes steel, wherein the chromium volume includes metallic chromium, wherein the acid solution includes hydrochloric acid, wherein a temperature (T) and a molarity (M) of the hydrochloric acid is within a triangular space defined by (T,M) points of (21 °C, 2.4 M), (52 °C, 2.4 M), and (52 °C, 1.2 M), and wherein the etch rate is at least a factor of about 2 greater than an etch rate that would occur in an absence of the iron-comprising body.

29. The electrical structure of claim 18, wherein the iron-comprising body includes steel, wherein the chromium volume includes metallic chromium, wherein the acid solution includes hydrochloric acid, wherein a temperature (T) and a molarity (M) of the hydrochloric acid is within a triangular space defined by (T,M) points of (21 °C, 2.4 M), (52 °C, 2.4 M), and (52 °C, 1.2 M), and wherein the etch rate is at least about 5 Å/second.

30. The electrical structure of claim 18, further comprising a flouropolymer dielectric volume bonded to said chromium volume.

ACCELERATED ETCHING OF CHROMIUM

Abstract of the Disclosure

A method and associated structure for increasing the rate at which a chromium volume is etched when the chromium body is contacted by an acid solution such as hydrochloric acid. The etch rate is increased by a metallic or steel body in continuous electrical contact with the chromium volume, both of which are in continuous contact with the acid solution. At a temperature between about 21 °C and about 52 °C, and a hydrochloric acid concentration (molarity) between about 1.2 M and about 2.4 M, the etch rate is at least a factor of about two greater than an etch rate that would occur in an absence of the steel body. In one embodiment, the chromium volume is a chromium layer that rests upon a conductive layer that includes a metal such as copper, wherein the acid solution is not in contact with the conductive layer. In another embodiment, the chromium volume is a chromium layer located under a conductive layer that includes a metal such as copper, wherein the steel body and the acid solution both contact the chromium layer through an opening in the conductive layer such that the opening exposes the chromium layer.

FARQUHAR ET AL

END000006 US1

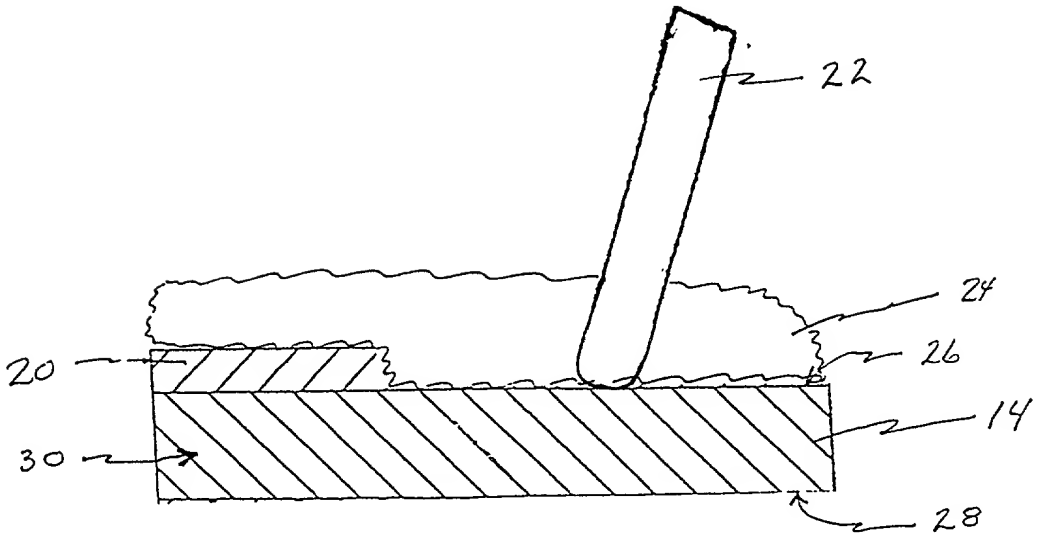

Fig. 1

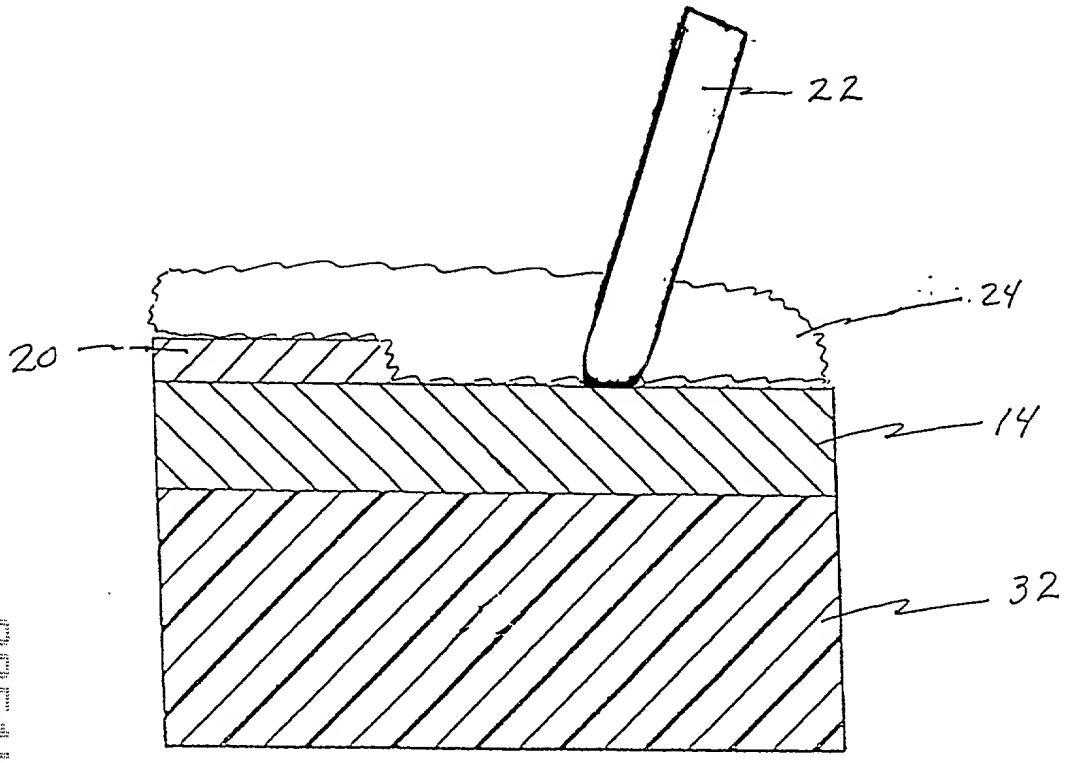

Fig. 2

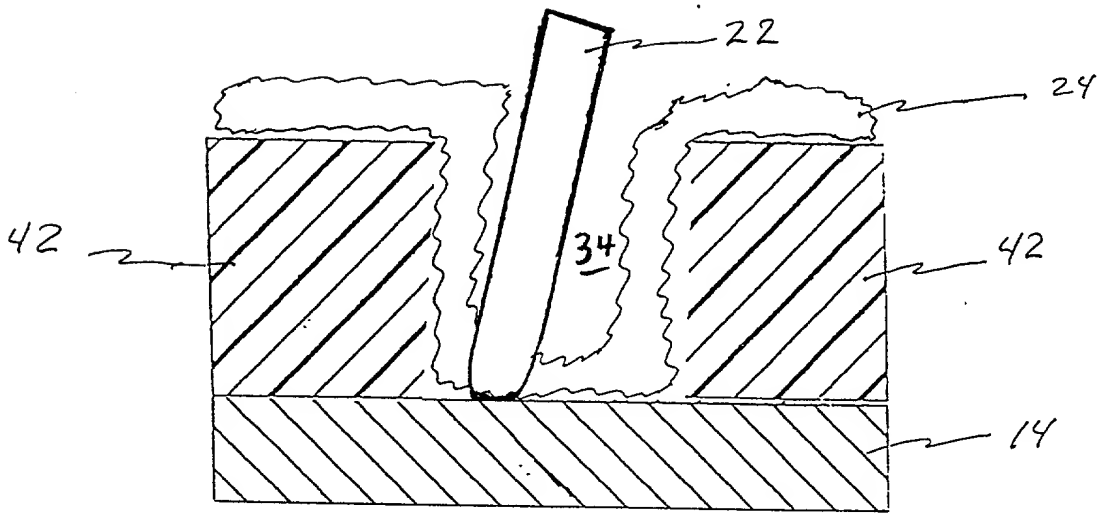

Fig. 3

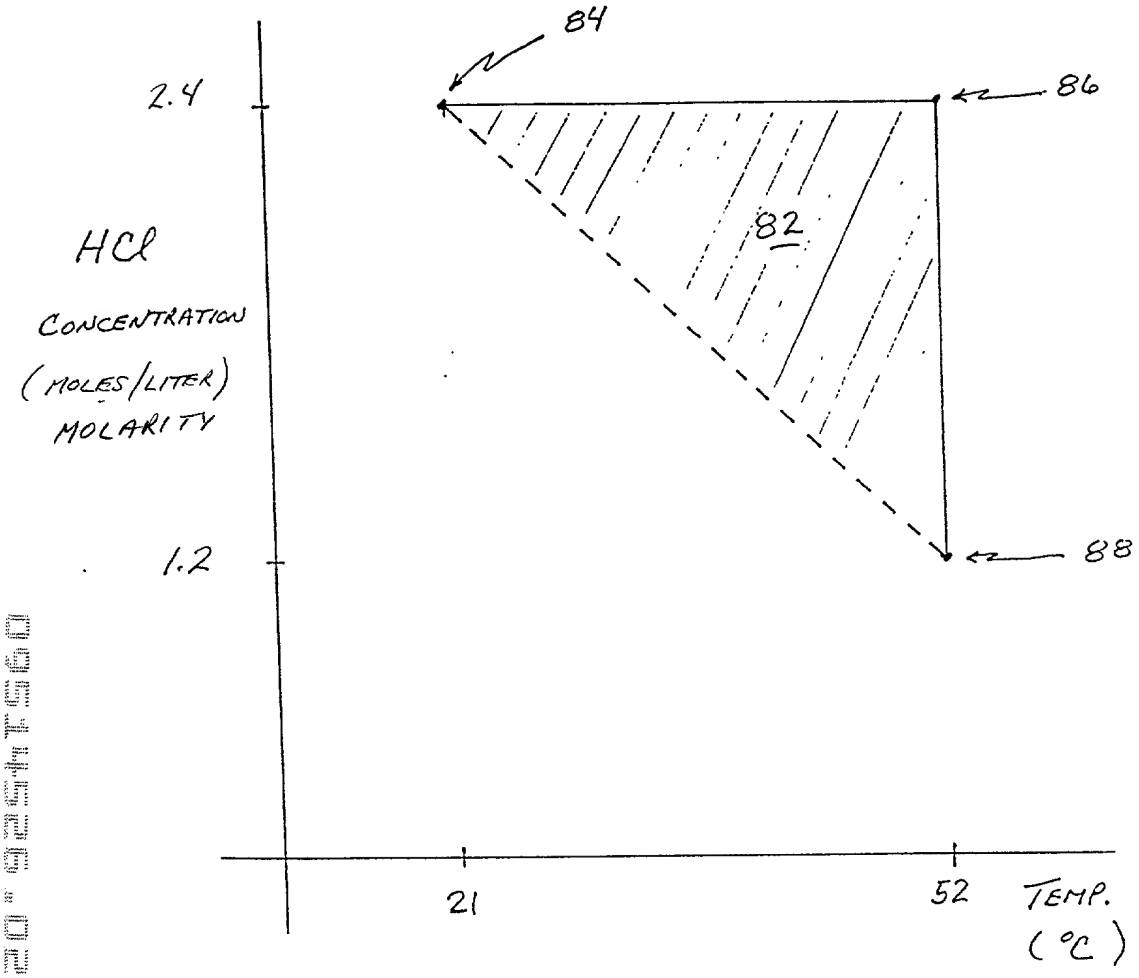

FIG. 4

Docket No.
END000006US1

Declaration and Power of Attorney For Patent Application

English Language Declaration

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

ACCELERATED ETCHING OF CHROMIUM

the specification of which

(check one)

☒ is attached hereto.

☐ was filed on _____ as United States Application No. or PCT International Application Number _____

and was amended on _____

(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)			Priority Not Claimed
_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)	☐
_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)	☐
_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)	☐

I hereby claim the benefit under 35 U.S.C. Section 119(e) of any United States provisional application(s) listed below:

(Application Serial No.)	(Filing Date)

I hereby claim the benefit under 35 U. S. C. Section 120 of any United States application(s), or Section 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, C. F. R., Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

Albert L. Schmeiser-30,681
Arlen L. Olsen-37,543
John A. Merecki-35,812
S. Jared Pitts-38,579
Kristen L. Ashdown-43,682
Jack P. Friedman-44,688
Robert J. Mauri-41,180
Ziye Zhou-41,423
Jared S. Goff-44,716
David L. Adour-29,604
Lawrence R. Fraley-26,885
John R. Pivnichny-43,001
Arthur J. Samodovitz-31,297
William H. Steinberg-28,540
Christopher A. Hughes-26,914
Edward A. Pennington-32,588
John E. Hoel-26,279
Joseph C. Redmond, Jr.-18,753

Send Correspondence to: **Jack P. Friedman**
Schmeiser, Olsen & Watts
3 Lear Jet Lane, Suite 201
Latham, NY 12110

Direct Telephone Calls to: *(name and telephone number)*
Jack P. Friedman (518) 220-1850

Full name of sole or first inventor
Donald S. Farquhar

Sole or first inventor's signature — Date
Donald S Farquhar — Feb 22, 2000

Residence
1106 Rodman Road, Endicott, NY 13760

Citizenship
USA

Post Office Address
Sane as Residence

Full name of second inventor, if any
Edmond O. Fey

Second inventor's signature — Date
Edmond O. Fey — 2/24/00

Residence
192 Sheedy Road, Vestal, NY 13850

Citizenship
USA

Post Office Address
Same as Residence

Full name of third inventor, if any
Elizabeth Foster

Third inventor's signature
Elizabeth Foster
Date
2/22/2000

Residence
RR#1, Box 1676, Friendsville, PA 18818

Citizenship
USA

Post Office Address
Same as Residence

Full name of fourth inventor, if any
Michael J. Klodowski

Fourth inventor's signature
Michael J. Klodowski
Date
2/24/00

Residence
937 Sarah Lane, Endicott, NY 13760

Citizenship
USA

Post Office Address
Same as Residence

Full name of fifth inventor, if any
Paul G. Rickerl

Fifth inventor's signature
Paul G. Rickerl
Date
2/21/2000

Residence
403 Tilbury Hill Road, Endicott, NY 13760

Citizenship
USA

Post Office Address
Same as Residence

Full name of sixth inventor, if any

Sixth inventor's signature
Date

Residence

Citizenship

Post Office Address